

NE-1081

- 23 -

What is claimed is:

- 1 1. A network node for a communications network which
- 2 comprises a plurality of network nodes interconnected by communication
- 3 links, wherein said network node is one of said plurality of network nodes,
- 4 comprising:
- 5 a first module, having a plurality of input ports and a plurality of
- 6 output ports, for handling a group of channels between said input ports and
- 7 said output ports as a routing unit;
- 8 a second module, having an input port and an output port, for
- 9 handling a channel between the input port and the output port as said
- 10 routing unit;
- 11 a module state database for storing module cost data of said first and
- 12 second modules and module cost data of other network nodes;
- 13 a link state database for storing link cost data of said communication
- 14 links, and
- 15 a switching system for determining a route of minimum cost by using
- 16 said module state database and said link state database and establishing,
- 17 according to the determined route, a connection between one of a plurality of
- 18 incoming communication links and one of the input ports of said first and
- 19 second modules and establishing a connection between one of the output
- 20 ports of said first and second modules and one of a plurality of outgoing
- 21 communication links.

- 1 2. The network node of claim 1, wherein said switching system

NE-1081

- 24 -

2 determines said route of minimum cost by:
3 detecting available links along possible routes in said link state
4 database and detecting available first and second modules in said module
5 state database;
6 forming a plurality of candidate paths by using the available links and
7 the available first and second modules;
8 calculating costs of said candidate paths by using said module and link
9 state database; and
10 determining one of said candidate paths having a minimum value of
11 the calculated costs as said route of minimum cost.

1 3. The network node of claim 1, wherein the network node is an
2 intermediate node between first and second network nodes, and wherein said
3 link state database includes a first plurality of link entries for storing status of
4 links to said first and second network nodes and a second plurality of link
5 entries for storing status of forwarding adjacency links between said first and
6 second network nodes, said second plurality of link entries containing a total
7 cost of said links and said modules.

1 4. The network node of claim 1, wherein said switching system is
2 an optical switching system, and said incoming and outgoing links are optical
3 links and said channels are wavelength channels.

1 5. The network node of claim 4, wherein said first module
2 comprises an optical switch module for simultaneously establishing a

NE-1081

- 25 -

3 plurality of connections between said plurality of input ports and said
4 plurality of output ports for carrying a plurality of said wavelength channels
5 and said second module comprises an optical switch module for establishing
6 a connection at a time between said input port and said output port for
7 carrying a wavelength channel.

1 6. The network node of claim 5, wherein said second module is
2 capable of converting the wavelength of said wavelength channel to a
3 different wavelength.

1 7. The network node of claim 4, wherein said first module
2 comprises an optical regenerator module for simultaneously performing an
3 optical regeneration process on a plurality of said wavelength channels.

1 8. The network node of claim 4, wherein said second module
2 comprises an optical regenerator module for performing an optical
3 regeneration process on a wavelength channel.

1 9. The network node of claim 4, wherein a plurality of
2 wavelengths are multiplexed on each of said incoming links and each of said
3 outgoing links, and wherein said first module simultaneously handles said
4 multiplexed wavelengths as said routing unit and said second module selects
5 one of the multiplexed wavelengths for handling the selected wavelength as
6 said routing unit.

NE-1081

- 26 -

1 10. The network node of claim 1, wherein the network node is an
2 intermediate node between first and second network nodes, and wherein said
3 link state database includes a plurality of physical link entries for storing
4 status of links to each of said first and second network nodes and a plurality
5 of virtual link entries for storing status of concatenated links between said
6 first and second network nodes, said virtual link entries containing a cost of
7 each of said virtual links.

1 11. The network node of claim 1, further comprising terminating
2 circuitry for transmitting a message to neighboring network nodes for
3 communicating the contents of said module and link state databases and
4 receiving a message from said neighboring network nodes for updating said
5 module and link state databases according to the received message.

1 12. A communications network comprising:
2 a plurality of network nodes interconnected by a plurality of incoming
3 communication links and a plurality of outgoing communication links,
4 each of said network nodes comprising:
5 a first module, having a plurality of input ports and a plurality
6 of output ports, for handling a group of channels between said input ports
7 and said output ports as a routing unit;
8 a second module, having an input port and an output port, for
9 handling a channel between the input port and the output port as said
10 routing unit;
11 a module state database for storing module cost data of said

NE-1081

- 27 -

12 first and second modules and module cost data of other network nodes;
13 a link state database for storing link cost of each of said
14 incoming links and each of said outgoing links,
15 a switching system for determining a route of minimum cost by
16 using said module state database and said link state database and
17 establishing, according to the determined route, a connection between one of
18 the incoming communication links and one of the input ports of said first and
19 second modules and establishing a connection between one of the output
20 ports of said first and second modules and one of said outgoing
21 communication links; and
22 terminating circuitry for transmitting a message to neighboring
23 network nodes for communicating the contents of said module state database
24 and receiving a message from said neighboring network nodes for updating
25 said module state database according to the received message.

1 13. The communications network of claim 12, wherein said
2 switching system determines said route of minimum cost by:
3 detecting available links along possible routes in said link state
4 database and detecting available first and second modules in said module
5 state database;
6 forming a plurality of candidate paths by using the available links and
7 the available first and second modules;
8 calculating costs of said candidate paths by using said module and link
9 state database; and
10 determining one of said candidate paths having a minimum value of

NE-1081

- 28 -

11 the calculated costs as said route of minimum cost.

1 14. The communications network of claim 12, wherein said each
2 network node is an intermediate node between first and second network
3 nodes, and wherein said link state database includes a plurality of link entries
4 for storing status of links to each of said first and second network nodes and
5 a plurality of channel entries for storing status of channels between said first
6 and second network nodes, said channel entries containing a total cost of said
7 channels and said modules.

1 15. The communications network of claim 12, wherein said
2 switching system is an optical switching system, and said incoming and
3 outgoing links are optical links and said channels are wavelength channels.

1 16. The communications network of claim 15, wherein said first
2 module comprises an optical switch module for simultaneously establishing a
3 plurality of connections between said plurality of input ports and said
4 plurality of output ports for carrying a plurality of said wavelength channels
5 and said second module comprises an optical switch module for establishing
6 a connection at a time between said input port and said output port for
7 carrying a wavelength channel.

1 17. The communications network of claim 16, wherein said second
2 module is capable of converting the wavelength of said wavelength channel
3 to a different wavelength.

[illegible]

NE-1081

- 29 -

1 18. The communications network of claim 16, wherein said first
2 module comprises an optical regenerator module for simultaneously
3 performing an optical regeneration process on a plurality of said wavelength
4 channels.

1 19. The communications network of claim 16, wherein said second
2 module comprises an optical regenerator module for performing an optical
3 regeneration process on a wavelength channel.

1 20. The communications network of claim 16, wherein a plurality of
2 wavelengths are multiplexed on each of said incoming links and each of said
3 outgoing links, and wherein said first module simultaneously handles said
4 multiplexed wavelengths as said routing unit and said second module selects
5 one of the multiplexed wavelengths for handling the selected wavelength as
6 said routing unit.

21. The communications network of claim 12, wherein said each network node is an intermediate node between first and second network nodes, and wherein said link state database includes a first plurality of link entries for storing status of links to said first and second network nodes and a second plurality of link entries for storing status of forwarding adjacency links between said first and second network nodes, said second plurality of link entries containing a total cost of said links and said modules.

1 22. A centralized network management system comprising:

NE-1081

- 30 -

2 a plurality of network nodes interconnected by communication links;

3 a management center connected to said network nodes via control

4 channels,

5 each of said network nodes comprising:

6 a first module, having a plurality of input ports and a plurality

7 of output ports, for handling a group of channels between said input ports

8 and said output ports as a routing unit;

9 a second module, having an input port and an output port, for

10 handling a channel between the input port and the output port as said

11 routing unit; and

12 a switching fabric having a plurality of incoming interfaces for

13 interfacing incoming links and a plurality of outgoing interfaces for

14 interfacing outgoing links; and

15 said management center comprising:

```
16         a module state database;
```

17 a link state database for storing link cost of each of said

18 incoming links and each of said outgoing links; and

19 a path controller for storing module cost data of said first and

20 second modules of each of said network nodes into said module state

21 database and determining a route of minimum cost by using said module

22 state database and said link state database and controlling said switching

23 fabric to establish a connection between one of the incoming interfaces and

24 one of the input ports of said first and second modules and establish a

25 connection between one of the output ports of said first and second modules

26 and one of said outgoing interfaces.

NE-1081

- 31 -

23. The centralized network management system of claim 22,
wherein said path controller determines said route of minimum cost by:
detecting available links along possible routes in said link state
database and detecting available first and second modules in said module
state database;
forming a plurality of candidate paths by using the available links and
the available first and second modules;
calculating costs of said candidate paths by using said module and link
state database; and
determining one of said candidate paths having a minimum value of
the calculated costs as said route of minimum cost.

1 24. The centralized network management system of claim 22,
2 wherein said each network node is an intermediate node between first and
3 second network nodes, and wherein said link state database includes a
4 first plurality of link entries for storing status of links to said first and second
5 network nodes and a second plurality of link entries for storing status of
6 forwarding adjacency links between said first and second network nodes,
7 said second plurality of link entries containing a total cost of said links and
8 said modules.

1 25. The centralized network management system of claim 22,
2 wherein said switching fabric is an optical switching fabric, and said
3 incoming and outgoing links are optical links and said channels are
4 wavelength channels.

[illegible]

NE-1081

- 32 -

1 26. The centralized network management system of claim 25,
2 wherein said first module comprises an optical switch module for
3 simultaneously establishing a plurality of connections between said plurality
4 of input ports and said plurality of output ports for carrying a plurality of
5 said wavelength channels and said second module comprises an optical
6 switch module for establishing a connection at a time between said input port
7 and said output port for carrying a wavelength channel.

1 27. The centralized network management system of claim 26,
2 wherein said second module is capable of converting the wavelength of said
3 wavelength channel to a different wavelength.

1 28. The centralized network management system of claim 25,
2 wherein said first module comprises an optical regenerator module for
3 simultaneously performing an optical regeneration process on a plurality of
4 said wavelength channels.

1 29. The centralized network management system of claim 26,
2 wherein said second module comprises an optical regenerator module for
3 performing an optical regeneration process on a wavelength channel.

1 30. The centralized network management system of claim 25,
2 wherein a plurality of wavelengths are multiplexed on each of said incoming
3 links and each of said outgoing links, and wherein said first module
4 simultaneously handles said multiplexed wavelengths as said routing unit

NE-1081

- 33 -

5 and said second module selects one of the multiplexed wavelengths for
6 handling the selected wavelength as said routing unit.

31. The centralized network management system of claim 22,
wherein said each network node is an intermediate node between first and
second network nodes, and wherein said link state database includes a first
plurality of link entries for storing status of links to said first and second
network nodes and a second plurality of link entries for storing status of
forwarding adjacency links between said first and second network nodes,
said second plurality of link entries containing a total cost of said links and
said modules.

32. A routing method comprising the steps of:

- a) providing, in each of a plurality of network nodes interconnected by communication links, a first module having a plurality of input ports and a plurality of output ports, the first module handling a group of channels between said input ports and said output ports as a routing unit;
- b) providing, in each of a plurality of network nodes, a second module having an input port and an output port, the second module handling a channel between the input port and the output port as said routing unit;
- c) storing module cost data of said first and second modules of said plurality of network nodes in a module state database;
- d) storing link cost of said communication links in a link state database; and

NE-1081

- 34 -

- 14 e) determining a route of minimum cost by using said module
15 state database and said link state database.

- 1 33. The method of claim 32, wherein the step (e) comprises the
2 steps of:
3 detecting available links along possible routes in said link state
4 database and detecting available first and second modules in said module
5 state database;
6 forming a plurality of candidate paths by using the available links and
7 the available first and second modules;
8 calculating costs of said candidate paths by using said module and link
9 state database; and
10 determining one of said candidate paths having a minimum value of
11 the calculated costs as said route of minimum cost.

1003404 : 030303